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*Research in
Network Data Management and
Resource Sharing*

Application Summary

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Research in Network Data Management
and
Resource Sharing

Application Summary

by

Peter A. Alsberg

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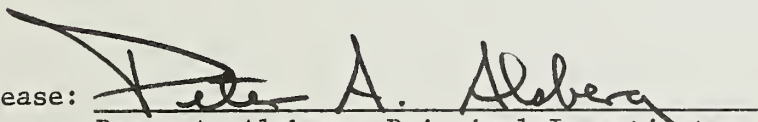

Peter A. Alsberg, Principal Investigator

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Introduction

The Center for Advanced Computation of the University of Illinois at Urbana-Champaign is preparing a three year research plan to develop network data management and a resource sharing technology for application in the World-Wide Military Command and Control System (WWMCCS) Intercomputer Network (WIN). This work is supported by the Joint Technical Support Activity of the Defense Communications Agency.

As part of the preparation of the Research Plan, interviews were conducted with 25 military and 9 civilian personnel at CINCPAC, NMCSSC, PMO, and REDCOM. Six PWIN systems were reviewed including the Network Control Program (NCP), Network Accounting Program (NAP), Telnet, File Transfer Protocol (FTP), Network Control Language (NCL), and Workload Sharing (WLS). Four GCOS based single site systems were reviewed including the World Wide Data Management System (WWDMS), Timesharing System (TSS), Transaction Processing System (TPS), and Network Processing System (NPS). The purpose of these interviews and reviews was to assess the needs of the WWMCCS community as perceived by the actual users of the proposed WWMCCS Intercomputer Network and to assess current PWIN and GCOS problem approaches so that both user needs and current activities could be appropriately integrated into the three year research plan. This report summarizes the major technology requirements of WWMCCS applications as indicated by the site interviews and system reviews. A companion report, the Technology Summary, summarizes the state-of-the-art in network data management and related technology and indicates research and development priorities dictated by technology interdependencies.

Principal Findings

Research and Development Needs

Research and development is needed to support WWMCCS applications in five major areas: security, the human interface, structured data, narrative data, and survivability. These areas are described in the order of their impact on and importance to the development of a working WWMCCS networking facility.

Security. Until an appropriate security technology is developed, the utilization of WWMCCS computing resources will be inefficient and the ability to share resources over a computer network will be minimal or nonexistent.

The human interface. Current WWMCCS software systems are not usable by personnel without extensive training. The human interfaces are inappropriate to DOD personnel and can be ineffective during crisis management.

Structured data. There is technology for the processing of structured data which already exists and is needed by the WWMCCS community but is not being utilized by that community. A technology transfer program is required to move this technology into the operational world. In addition, the size of WWMCCS data bases and the interactive exploration of those data bases are beyond current data processing technology and will require the development of new technology.

Narrative Data. A great deal of command data is in narrative reports and other text forms. The automatic processing of that data is inadequate at present and major technological assistance is not likely in the 5-10 year time frame.

Survivability. At present the WWMCCS Intercomputer Network does not have a goal of providing survivable operations. The lack of this goal and the concept of nonsurvivable computer support are of grave concern in the user community.

Community Experience and Orientation

Intercomputer networking is a very new and sophisticated technology which is foreign to the previous experience and orientation of the WWMCCS community. In order to make this technology serve that community, the community must understand the difficulty and scope of networking technology. There are three current areas of concern here: an appreciation of the immaturity of the technology, the batch orientation of the community, and the appropriateness of GCOS for networking.

Appreciation of the immaturity of the technology. The high degree of sophistication of intercomputer network technology and the poor state-of-the-art in resource sharing are not generally appreciated in the research or user communities. WWMCCS networking capabilities will be based on the well researched ARPA network communications technology. A sound communications network is required to support a resource sharing intercomputer network. However, almost no work has been done to develop the actual resource sharing technology that will live on top of this communications network.

Batch orientation of the community. The ADP community in general and the WWMCCS ADP community in particular have a strong batch orientation. Many of the systems being developed for the WWMCCS Intercomputer Network take a batch approach. Unfortunately, the command function is a highly interactive function and bears little resemblance to batch operations. Also, intercomputer networking is an inherently interactive technology as opposed to a batch technology.

Appropriateness of GCOS for networking. GCOS is an efficient single site batch system which is a natural choice for a batch oriented ADP community. However, a careful study by SDC has concluded that GCOS is not secure and cannot be made to provide secure operations for WWMCCS network applications. In addition, our superficial review of GCOS and the manner in which PWIN systems must be forced into GCOS indicate that GCOS may not be a viable base for an interactive inter-computer network.

Research and Development Needs

Security

Pervasiveness of security. Security is a pervasive concern and must be considered in all components of a functioning system. For example, an operating system may be secure and provide the appropriate support for the development of secure subsystems. However, a data management system shared by several users within that operating system can readily violate security axioms and improperly disclose information to any of its users. The data management system must also be secured and must correctly cooperate with the secured operating system to insure the security of both. In general, security must be addressed in every application package. It is inherently a "systems" problem.

Impact on technology development. Since security affects every component of a system it must always be considered even when developing new technologies for intercomputer networking in research and development activities. Security itself is an area of intense research activity and it is likely that systems which are demonstrably secure in a very restricted, well-defined sense will be developed shortly.

Impact on WWMCCS efficiency and networking. In the WWMCCS community, the lack of multi-level security adversely affects resource utilization. In order to change security classification whole machines and rooms must be cleaned. This means that lines may have to be broken, disk packs have to be exchanged, core memories have to be cleared, etc. The process can easily take an hour or two. Not only does the cleaning process itself remove valuable computational resources from productive work, but it also blocks the ready sharing of secret and top-secret data

bases in some applications. Because multi-level security is not currently supported and even compartments within a security level cannot share a facility, a whole site must run at one classification level and one compartment within that level. This is intolerable in a resource sharing network where all cooperating sites on the network would have to run within the same compartment at the same level in order to share resources. Unless this problem is solved and multi-level security implemented on the network, effective resource sharing will be blocked.

Human Interface

Current interfaces. At present, the human interfaces to existing and proposed WWMCCS systems simply don't work. Operation of the systems requires trained personnel. Furthermore, like virtually all time-sharing and batch systems, constant use of the system is required in order to maintain familiarity and skill. In normal peacetime operations only one shift of operators has this day-to-day usage and develops this skill. In a crisis situation, when a command center is manned on a three-shift basis, most of the operations personnel will lack the skill and hence the competence to effectively use the system. Telephone, facsimile, and other easy-to-use facilities will be used to avoid fumbling with the computer system.

Training requirements. The extremely mobile DOD personnel have a distinctive access pattern. The DOD user may have a week or a month of training on the use of a system, followed by a few weeks or a few months of actual use, after which he may not again see the system for perhaps a year or more. At the time he is reintroduced to the system, after this long lapse, he requires retraining in order to again use the system.

Interactive requirements. Sensitivity to interactive capabilities is a critical issue. The WWMCCS ADP support community tends to think in terms of batch processing. Thus, a delivery of large listings to decision makers once a day or every few hours in a crisis situation is a normal decision maker interface. The decision maker doesn't really want to see another two-inch listing with 10,000 numbers. What he wants to see are the five numbers that tell him what the 10,000 numbers mean. Getting those five critical numbers is a process that requires interactive, exploratory access to some very large WWMCCS data bases.

Existing technology. A great deal can be done within existing technology just by being sensitive to the user interface problem and applying some creativity when designing the interface. For example, application systems should be designed with tutorial capabilities built in. It then becomes feasible to consider an adaptive system that maintains a profile for each user and chooses terse paths through the application package for the familiar user and tutorial paths through the various components with which the user is not familiar.

Research requirements. Basic research is required in behavioral science areas in order to understand how a computer can best interact with a human. The engineer charged with the designing of a specific user interface needs to be able to quantify trade-offs such as when a visual response is better than an audio response, what kinds of input devices are best in what situations, or how displays are best configured for command situations when fatigue, high pressure, low pressure, or other factors are present.

Structured Data

Structured data are those data which are well organized and compartmentalized; for example, into records and fields. They are

sometimes referred to as pattern data or fact data. The need for structured data processing capabilities breaks into two categories: existing technology that needs to be transferred and technology that does not exist and needs to be developed.

Existing technology. There are many existing data management techniques which can be used with significant impact in the WWMCCS community. For example, the use of data compression facilities can produce 3:1 or greater reductions in secondary storage requirements and some reduction in CPU load. The judicious use of appropriate indexing techniques can significantly improve system response time. As an example, consider the planning of a joint operation. One of the first steps in planning a joint operation is to build a small working file of the airfields that might be used in the operation. In order to build the small file, a very large airfields file is accessed. The airfields file is stored on over 20 reels of tape. The file could be compressed to fit on a single DSS/190 disk pack (an IBM 3330 equivalent) and be made much more readily accessible to begin joint operation planning.

New technology. New technology is needed to be able to interactively manage a large data base (on the order of 50 million to 100 million bytes). A real time data management system is desperately needed. The current GCOS approach of submitting a query in TSS which then spawns a batch run is unacceptable. It does not provide timely access to the data base and, in effect, prohibits exploratory access to the data base. In order to support interactive access to a large data base, the data base will have to be physically structured to conform to the type of request being asked. Over time and particularly during crisis situations, the data accessed and the nature of the access will change. The data management systems will have to be self tuning so that

they can dynamically restructure their data to conform to recent patterns of user access. The Joint Operation Planning System (JOPS) is an ideal candidate for a self-tuning, dynamic data management system.

Narrative Data

Processing needs. Narrative data are textual data found in reports, messages, and commanders' comments in some data files. A great deal of command relevant data, particularly intelligence data, are in narrative form. At present, narrative data in the form of messages alone are so voluminous that it is hard to even route them correctly, much less analyze them. In addition, there is a serious problem in the timely transmission of messages.

Research difficulty. Systems to improve the transmission speed of messages are being developed now and have a high probability of success. The problem of automatically analyzing narrative data is much more difficult. Even the problem of automatically generating indices based on message content is technically very difficult. Both of these problems are in the realm of artificial intelligence and are not likely to be solved in the near future. While the problem of narrative data analysis is extremely difficult and not amenable to any quick solution, there may be some hope in the generation of indices to assist in message routing. A hybrid system, using manual coders augmented by a simple keyword extraction indexing scheme, may provide some modest assistance.

Survivability

Community concerns. At present, survivability is not a goal of the WWMCCS Intercomputer Network and little research or development emphasis is being placed on that problem. This is of great concern in the user community. In order to maintain continuity of operations during system failure, a program of graceful degradation from complete

computer support through partial computer support to completely manual systems must be available. At present, there are already some computer based systems for which no manual backup exists. Furthermore, even when old manual systems do exist, they tend to atrophy from lack of use.

Research directions. In the development of future WWMCCS network applications the designers should constantly bear in mind how the system can smoothly degrade to manual backup, should that be required. Furthermore, it appears there is a great deal that can be done, in a technical fashion, through the exploitation of appropriate network protocols, front-end computers, and intelligent terminals to dramatically improve the survivability of the WWMCCS network. This latter area is a research area which is receiving very little attention.

Community Experience and Orientation

Appreciation of the Immaturity of the Technology

Technology base. There is a great deal of emphasis being

placed on the development of resource sharing capabilities in the PWIN when the research needed to support that development has not been done and an understanding of basic problems does not exist. The WWMCCS network is based on ARPA network technology. The ARPA network is the most advanced of the "resource sharing" networks. Unfortunately, ARPA network research and development was almost all on the development of the communications technology which is required to support a resource sharing intercomputer network. Outside of some small demonstration projects of extremely limited scope, no automated resource sharing research, much less development, has been done.

Research vs. production networking. Much of the ARPA network

technology is research oriented and not directly exportable to production WWMCCS networking. For example, all of the ARPA network protocols assume a benign environment. During protocol execution it is assumed that there are no communication network failures, no host failures, no software errors, and that all the hosts cooperating on the network have honorable intentions. In moving to the WWMCCS environment, protocols need to be redesigned to take a realistic, production environment into account and to make the protocols resilient to network, host, software, and malevolent host problems. In addition to resiliency, security must also be addressed for each protocol.

Upgrading ARPA technology. Computer networking is a very new

and sophisticated technology. A thorough understanding of the ARPA network and its problems is a requirement for continued development.

Virtually all of the ARPA network technology is in need of a significant upgrade before it can be useful on the PWIN. Some of the PWIN concepts are improvements over ARPA concepts. For example, the NCP has some very interesting features for a production network and the NCL also has some new and favorable concepts. However, there are serious errors and steps backward from ARPA technology in other areas. For example, the Telnet capability is much less flexible and is unusable in a heterogeneous environment. All of the PWIN protocols fail to address problems of resiliency, and, because the security problem is ill-defined and unsolved in the network environment, little attention is paid to security. Part of the problem of transferring ARPA technology to the PWIN is that most of the expertise is in the research community, but most of the PWIN development has been left to production oriented agencies without ARPA experience.

Upgrading single-site system technology. Much of the technology which works well on a single-site operating system or data management system fails to function at all when moved to a network environment. The basic problem is that the communication time between system modules takes micro-seconds at a single site and seconds over a distributed network. Some of the basic techniques for naming conventions, synchronization of processes and the prevention of deadlock which live at the heart of single-site systems must be redeveloped for resource sharing networks. This type of development has been traditionally supplied by the research community. Unfortunately, the agencies traditionally responsible for supporting this kind of work (e.g., ARPA and NSF) are not supporting research on resource sharing networks. If the research required to bring resource sharing networks to their promise is to be done, the WWMCCS community will have to do it.

Batch Orientation of the Community

Interactive functions on a command and control network. The command function is a highly interactive function. It is not batch-like. Furthermore, intercomputer networking is an inherently interactive technology and not a batch technology. ADP shops traditionally have lagged behind the state-of-the-art in computing. The WWMCCS ADP community is no exception. They are batch oriented and thus tend to come up with batch solutions to command and network functions.

User education. It is easy to be frustrated with the current batch facilities and most users are. Most of the users we interviewed felt that there must be a better way, but it is hard for the user to identify an appropriate development direction since he has little contact with state-of-the-art technology and, in particular, with interactive computing. The development of demonstration vehicles to show concepts to the user community will help create an understanding of the technological alternatives to solve their problems. This would give the users a basis on which to exercise some vision and would make the user community more able to direct an appropriate and responsive research and development effort.

Appropriateness of GCOS for networking

Batch efficiency. GCOS is an efficient single-site batch system. It is very old and based on a batch architecture with the primary goal of providing efficient batch services. At the time GCOS was developed, this was the only appropriate goal for computer systems due to the relative expense of hardware. Batch processing made the most efficient use of the expensive computing resources. New versions of GCOS were backward compatible with the older versions. Thus, the batch

orientation and architecture has been maintained and GCOS is a natural choice for a batch oriented ADP community like the WWMCCS community.

Interactive deficiencies. Unfortunately, GCOS has serious deficiencies in the areas of security and interactive services. The problem is one of fundamental system architecture. For example, the timesharing system is implemented as a single batch job. Thus, time-sharing cannot make use of multiple processors even if the interactive load would warrant it. Furthermore, the timesharing environment is not compatible with the batch environment. Timesharing jobs use different supervisor calls, compilers, etc. than batch jobs. Timesharing programs cannot be run under batch and batch programs cannot be run under time-sharing. The modification of GCOS to provide additional interactive facilities can be extremely complex because GCOS has been extensively patched and modified beyond its original design goals. It is currently very complicated and difficult to modify or debug. For example, the cost of adding a Telnet facility to GCOS timesharing on the PWIN requires modifications to both GCOS and TSS and is extremely expensive compared to adding a similar facility to a more current operating system.

Application restrictions. The restrictiveness of the GCOS architecture tends to restrict the range of application packages supported and raises large potential barriers to the development of appropriate application packages to properly support users. As an example, note that Telnet is inherently a timesharing application yet it is currently only implemented on the batch side of GCOS rather than in the more natural timesharing environment.

Other operating systems. These problems are shared in greater or lesser degree by all old batch oriented operating systems which have

been retrofitted with interactive capabilities. Systems like Honeywell's Multics, IBM's TSS, and Burroughs' MCP are newer operating system architectures designed from the ground up to provide interactive services and are more amenable to supporting network activities.

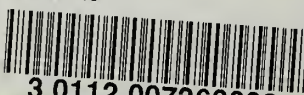
Security deficiencies. A careful study by SDC showed that GCOS is not secure and could not be made to provide secure operations for WWMCCS applications. As was indicated earlier, the support of multi-level security is a very basic requirement to enable effective resource sharing to proceed.

Need for a careful study. Our superficial reviews of PWIN systems and GCOS support systems have not been made at the same depth and quality as SDC's study. However, they do indicate, but by no means conclude, that GCOS may not be a viable base to support WWMCCS networking activities. A careful study should be undertaken at an early date to determine the range of GCOS capabilities and deficiencies in this environment. Should such a study show conclusively that GCOS is an inappropriate vehicle, then alternative vehicles must be considered.

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